PLANNING FOR EARTHQUAKE RESILIENCE IN HERITAGE SETTLEMENTS OF KATHMANDU VALLEY

A CASE OF BUNGAMATI

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CONTENT

INTRODUCTION

Kathmandu valley has a long history of organized settlements that can be traced back to about 1000 BC (Tiwari S. 2001). The valley today still houses many indigenous urban settlements :49 listed heritage settlements (MoUD, 2017); representing distinct social, political and built system. These heritage settlements, already at threat of urban decline and overlooked alongside Kathmandu valley's unplanned and rapid urbanization process, realized larger damaging impacts during the April 2015 major earthquake of M_w 7.8. As majority of these settlements were destroyed, there is an enormous challenge to reconstruct and recover the losses while orienting resilient urban growth. Post earthquake, the recovery process has been considerably slow with questionable generic reconstruction plans.

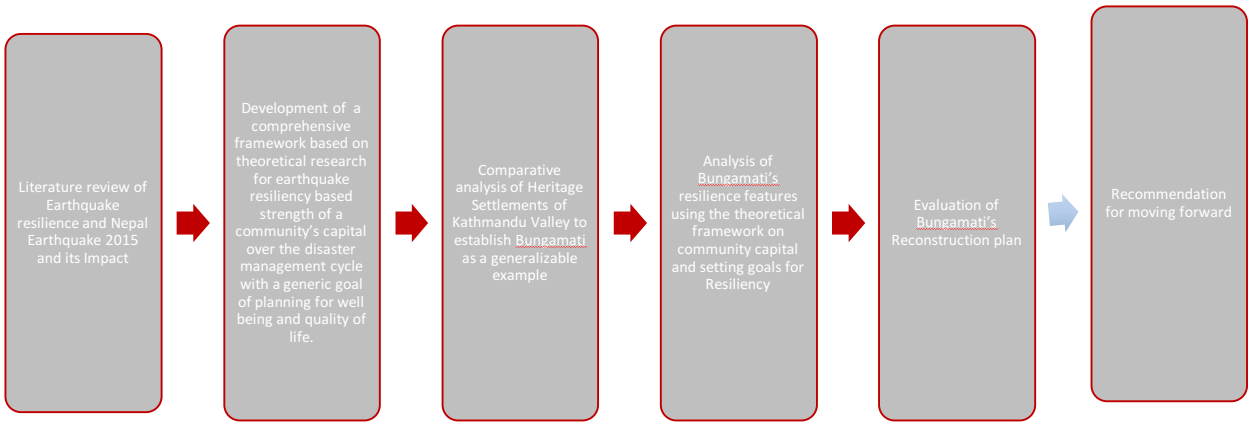
This research aims to understand what urban upgrading for disaster resilience looks like in the reconstruction process of traditional settlements in Kathmandu. The research intends to find an answer to: What does well being mean in heritage settlements and how does resilience planning ensure well being in a disaster prone heritage settlement? The study will combine empirical research and theoretical exploration on vulnerability and resilience at the intersection of community's well being and spatial connection (urban form, infrastructure systems) and governance (institution and social capital).

More specifically, the study takes Bungamati as a generalizable case for a heritage settlement of Kathmandu valley. Currently, "Rebuilding Bungamati"- the reconstruction planning for Bungamati is underway which includes an action plan, community participation and mobilization procedures and socio economic survey. The research will assess this rebuilding process and plan based on the conceptual framework developed to evaluate if "Rebuilding Bungamati" is better or worse in i) safeguarding the place identity ii) reducing vulnerability while ensuring resilience and better health and well being of its residents. It is equally important to make the analyses for the overall urban upgrading of heritage settlements i.e. with the lens of

sustainability while making sure that the upgraded settlement has well functioning systems prepared for next major earthquake.

Therefore, the knowledge gained out of the study might extend to useful application in formulating strategies for rebuilding as an outcome as well as process to heal the trauma of 2015 earthquake and build confidence to coexist with the inevitable earthquake events in future. Although, Bungamati is taken as typology, the research will try to identify the potential contextual distinctions between heritage settlements for more effective applicability.

METHODOLOGY



UNDERSTANDING EARTHQUAKE RESILIENCE

WHAT IS RESILIENCE? WHAT IS WELL BEING?

Resilience is a term first theorized within ecology that has expanded to the fields of urban studies, urban planning and design in recent years. Holling (1973) defines resilience as the "persistence of relationships within a system" and as "a measure of ability of the system to absorb disturbance before it restores the original balance or redefines its structure to a new stable state" (Holling 1973; Gunderson L et al. 2002; Peiwen Lu et al. 2013). Magis K (2010) explains community resilience as "the existence, development, and engagement of community resources by community members to thrive in an environment characterized by the inevitable nature of change, uncertainty, unpredictability and surprise". This disturbance or surprise can be slower processes of transformation in economic, social and environmental fields or a drastic one in the form of sudden shocks as disasters or wars (LSE. 2013; Peiwen Lu et al. 2013).

NRC (2011) characterizes disaster resiliency by reduced likelihood of damage and impact on critical infrastructure, lives, economic and social impacts; and reduced time to restore to normal or pre-disaster levels of functionality without escalating to catastrophic level of loss and impact. Thus, when applied to earthquakes, resilience is seismically-at risk area's ability to rebound after an earthquake. The places prone to earthquakes are uniquely sensitive and planning for earthquake resilience first requires understanding of what minimum impact to seismic hazard means at different timescale.

The impact is associated with the vulnerability (susceptibility to loss) of people, communities, their lifelines and economies (Adger W N. 2006; Menoni S et al. 2013); and is directly seen in the physical damage that further extends to social and economic consequences (French S P. et al. 2010). Vulnerability towards natural disaster is determined more by the pre-existing social, economic and political conditions than the event itself. Studies illustrate that socially vulnerable population with specific socioeconomic characteristics

as poor, elderly, children, women, renters, ethnical minorities have been differentially impacted by natural disasters (Frech S P et al.; Flanagan B E et al. 2011) and are less likely to recover.

Are the impacts minimum? This is directly linked to the four resilience dimensions of robustness, redundancy, resourcefulness and rapidity (Bruneau et al. 2003). Robustness is the overall strength of a system with the ability to withstand a stressor without failure. Redundancy is the existence of substitutable elements in the system allowing continuation of necessary services even when some elements fail. Resourcefulness is the ability to plan and implement disaster recovery based on established priorities and goals. Rapidity is the ability to carry out these activities quickly (Carpenter A. 2013)

Time is a significant factor in designing resilient communities. NRC (2011) breaks the timescale into Immediate <72 hours, Emergency: 3-7 days, Very short: 7-30 days, Short: 1- 6 months, Medium :6 months-1 year and Long>1 year. Broadly, there are four commonly adopted phases of disaster management cycle where resilience planning fits: Mitigation, Preparedness, Response and Recovery (FEMA) as shown in Fig. Mitigation is preventive and takes place prior to as well as after a hazard event in order to reduce chance of emergency happening or reduce damaging effects. Preparedness include plans or preparation to help the process of response and rescue. Response includes actions taken to save lives and prevent damage during emergency and involves putting preparedness plan into action. Recovery is defined as both restoration and enhancement and include actions taken to return to normal or safer state.

A normal state could be taken as when the community is functioning at its highest potential ensuring well being and quality of life for its people. According to CGIS (2017), indicators to a neighborhood's quality of life include quality of public safety, economy, accessibility, availability of services and housing affordability. Growing studies direct goals of well being and health at its center in rethinking development of cities where notion of health is not limited to absence of diseases but involves spatial, subjective or spiritual, political aspects as "freedom to lead a life we have reason to value", social competence through diversity, social connectivity, social justice, decision making for people to appropriate space, etc. (LSE Cities.2011). Sennet

R (2011) argues that social competence is key to an adult's quality of life and encounter to newness and diversity contribute to human maturity and it can be achieved through complexity in cities expressed through diversity and more connection between diverse groups and spaces. When applied to the state of disaster and collective trauma, adaptive governance characterized by strong linkages across spatial scales (local to national) and between sectors (government, community); social capital- bonds within and between social groups- organized volunteers, networks of social connection and mutual obligations; cultural capital (prestige) are key to enhance the resilience for well-being (Ross H et al. 2011; Lent C F. 2015). In catastrophic events like earthquakes when people do not have the sense of control over the event, chronic stress and anxiety associated with the event is traumatic and the emotional well being and mental health of people are at high risk that can translate into traumatic disorders, depression, etc. in long term. Strong social network and support without discrimination in the moment of crisis help achieve emotional resilience (Wheems C.F. et al. 2006). Social networks occur in different forms as familial, religious, political, economic, medical, educational, scientific, legal, risk management (insurance and first responders, etc.), mass media, communications, transportation, energy, food, water, leisure, entertainment, etc. (Carpenter A. 2013). However, communities that are more socially vulnerable and poverty stricken may lack the social ties that may actually help alleviate their situation in disaster.

As all societies are spatially manifested and organized, spatial decision through land use planning, design, density, street connectivity create space for social interactions and foster social capital (French et al. 1984; Carpenter A. 2013). Furthermore, literature on urban resilience attribute city's resilient characteristics to their urban form and spatial layout that can reflect and embody social pattern. Hillier B's space syntax theory provides that street network is the most significant component of built environment that holds cities together. As network shapes flows and spatial layout of networks helps us understand the movement patterns, it might be useful to approach resilience planning from network analyses.

COMPREHENSIVE FRAMEWORK FOR EARTHQUAKE RESILIENCE

To sum up, a community functions at all times depending on the capitals that it possesses seen in the form of natural, human, cultural, financial, built, political and social capitals. Magis K (2010) states that "community resilience is closely related to community capacity" and community capacity is the set of assets that exist within and among community's members, local associations and institutions. "How strong is the state of these capitals?" and "How well do the capitals interrelate one to form a collective action?" prior to as well as during and past a disastrous event, reflects the community's resilience. Thus, disaster resilience is an integrated and complex interplay of community's capitals grouped into five thematic areas as Ecological, Economic, Physical, Institutional and Social attributes. Stronger the thematic areas' capitals are, and more each area is connected to the other, higher the resilience of the entire system is.

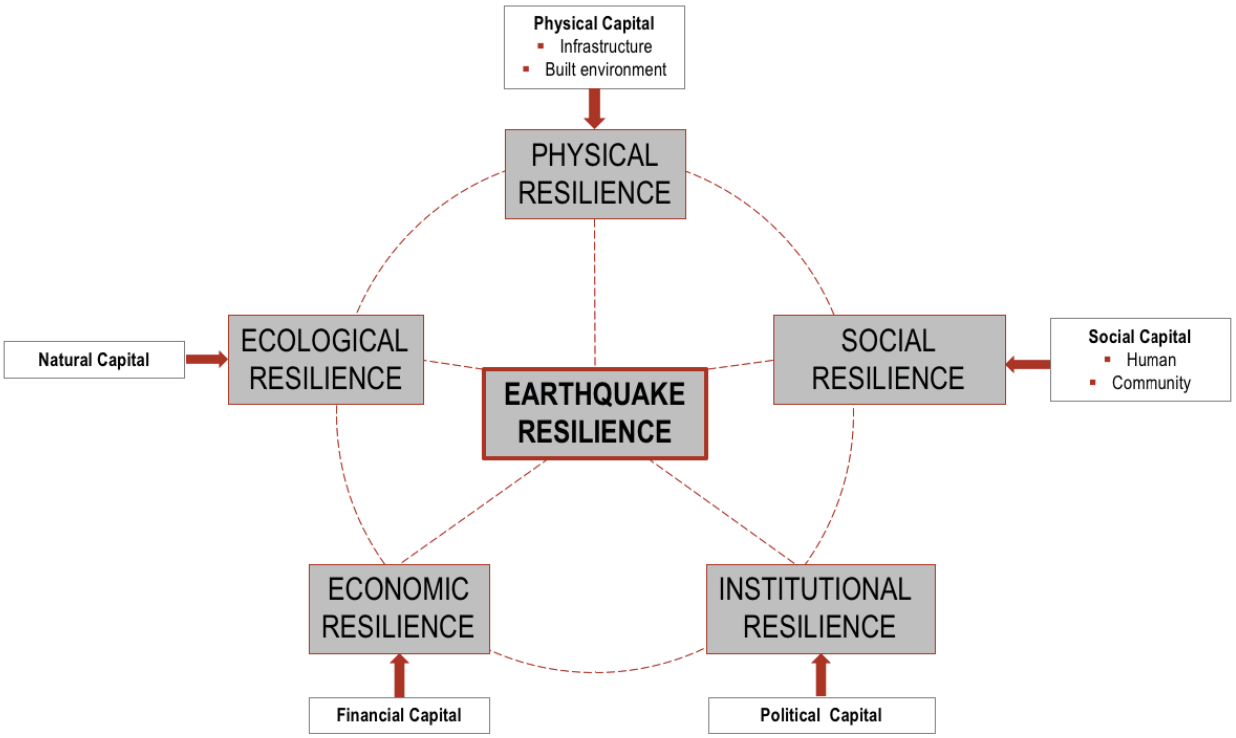


Figure 1: Integrated Earthquake Resilience conceptual diagram

Fig. illustrates a conceptual diagram of the interrelated nature of resilience and its capital and the Table below lists different aspects of the capitals that determine the strength of the capitals and hence the resilience of the community/systems.

Table 1. Strong vs. Weak Resilience based on Community or System's capital (Sources: Wilson G. 2009; Ziyath A M et al. 2013; LSE Cities.2013)

	Strongly Developed Capital	Weakly Developed Capital
Physical Resilience [Built capital, Infrastructure capital]	▪ Affordable housing ▪ Public spaces and landscape quality ▪ Aesthetics and place making ▪ Diverse land use ▪ Alternate and flexible uses ▪ Affordable transport ▪ Adequate infrastructure: water supply, power supply, communication systems ▪ Connected spatial network ▪ Variety of transportation choices (special needs) ▪ Evacuation centers ▪ Strong Earthquake resistant building and infrastructure systems ▪ Designed resilient urban forms (density, emergency access)	▪ Expensive and Low quality housing (vacancy, blight) ▪ Inadequate housing ▪ Poor or inexistent public spaces ▪ Inadequate and Poor infrastructures ▪ Isolated uses
Ecological Resilience [Natural capital]	▪ Good environment quality ▪ Predictable agricultural yields ▪ Biodiversity ▪ Preserved open space, farmland, natural beauty and critical environmental areas	▪ Poor environment quality ▪ Exploitation of natural resources ▪ Soil degradation
Social Resilience [Human capital, Social capital]	▪ Social competence: Skill, knowledge and education ▪ Good health and sanitation ▪ Inclusivity and equity ▪ Open minded community ▪ Community associations ▪ Tight-knit community ▪ Cultural heritage and values ▪ Volunteerism ▪ Psychological support system	▪ Unskilled human capital ▪ Outmigration of young population ▪ Service deserts ▪ Lack of leadership ▪ High death rate and low life expectancy ▪ Isolated community ▪ Too much homogeneity ▪ More vulnerable groups and social inequity (gender, ethnic, differently abled) ▪ Degrading social and cultural values
Economic Resilience [Financial capital]	▪ Diversified income streams ▪ Property values in wider urban context ▪ Low dependency on external funds	▪ Poverty/debt ▪ Unemployment ▪ Low income

	▪ Multifunctional businesses ▪ Integration into global capitalist systems ▪ Pensions, savings, credit facilities, welfare benefits, ▪ Wealth accumulation and Financing options ▪ Civic and social enterprise ▪ Resources to invest in business	▪ High dependency on external funding ▪ Net importer of goods and services ▪ Isolated business
Institutional Resilience [Political Capital]	▪ Equal participation in power and decision making ▪ Access to resources and fair resource allocation ▪ Strong governance structures at multiple geographical scales ▪ Local organizations and community institutions ▪ Regulation and policies to manage built environment, safety ▪ Development Plans ▪ Disaster Management plans	▪ Unequal representation ▪ Weak governance ▪ Absence of local organization ▪ Absence of strong policies and regulation ▪ Absence of development and disaster management plans

NEPAL EARTHQUAKE

SEISMIC FEATURES AND HISTORICAL EARTHQUAKES

Nepal is situated in the Himalayan concave chain, 870 km long in West- East direction and 130- 260 km long in North-South direction. The Himalayan belt is one of the most seismically active regions in the world because of the faulting between the sub ducting Indian Plate and the overriding Eurasian Plate to the north . The Indian plate converges with the Eurasian plate at a rate of approximately 45 mm/year towards the northeast for a 475 year return period earthquake with exceedance probability of 10% in 50 to 70 years with high peak ground acceleration(PGA) levels (EERI. 2016; Sharma et. Al. 2016; Chaulagain. H. et. al. 2015). From South to North, Nepal can be subdivided into five major tectonic zones separated from each other by major thrust faults (EERI. 2016). Moreover, most of Nepal falls in high intensity scale of MMI IX or above that make the country susceptible to high earthquake risk and hazard, evident in destructive local and regional earthquakes in the past with the most recent event in 2015.

Major historical earthquakes

Year	Magnitude M_L	Location	Impact
1255	7.8	Kathmandu	MMI intensity X, 1/3rd population killed, many houses and temples collapsed
1408	8.2	Nepal- Tibet Border, Bagmati zone	Severe damage and collapse of buildings and temples in Kathmandu valley; Rato Machhendranath temple destroyed
1681	8	Northern Kosi zone	Heave loss of lives and collapse and damage of buildings, temples
1767	-	-	21 aftershocks in 24 hours period reported.
1810	-	-	21 aftershocks in a month period. Small number of casualties, some buildings and temples severely damaged
1833	8	Kathmandu/Bihar (Phaplu)	18,000 houses collapsed, 4214 in kathmandu; Tower of Dharahara severely damaged, Thimi and bhaktapur destroyed
1916	7.7	Nepal/Tibet (Mt Api in western Nepal)	-
1934	8.4	Nepal- Bihar border	Strongest earthquake; MMI VII to X. Kathmandu valley experienced extreme damage. Most buildings destroyed in the

			three main cities- Kathmandu, Bhaktapur and Patan. 8519 death, More than 126,000 houses damaged, more than 80,000 buildings completely collapsed
1980	6.5 Ml	Darchula	125 deaths, 248 serious injury, 13,414 buildings damaged, 11,604 completely destroyed
1988	M6.9	Udaipur	722 killed Nepal and India, 12,000 injured, 65,000 buildings damaged.

Sources: National Seismological Center; DPNet Nepal.2017; EERI 2016, JICA and MOHA. 2002; NSET; Nepal Times

APRIL 2015, GORKHA EARTHQUAKE SEQUENCE

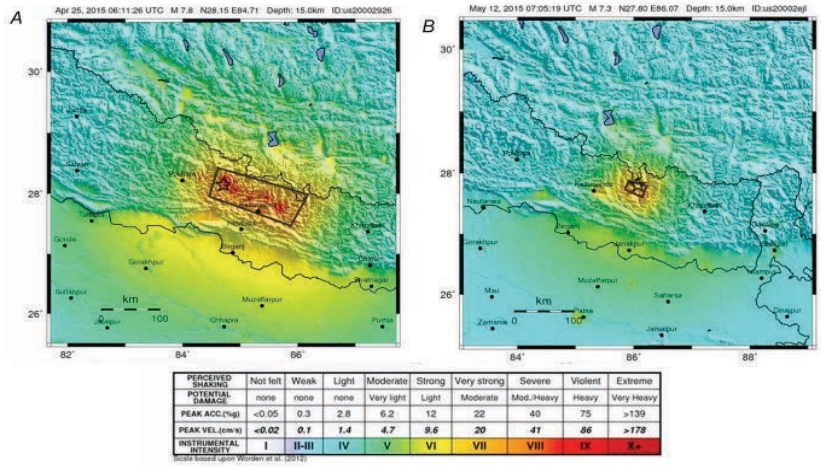


Figure 2: USGS ShakeMaps showing estimated seismic intensity in the central Nepal region from the M7.8 April 25, 2015 Gorkha earthquake (A), and the M7.3 May 12, 2015 aftershock (B)

On April 25th 2015, a major earthquake of moment magnitude M_W 7.8 struck at N28.147°, E84.708° near the village of Barpak in the historic district of Gorkha, about 76 km northwest of Kathmandu 11:56 a.m. local time. The earthquake occurred as a result of the faulting near the main thrust interface along a shallow decollement along the main Himalayan thrust between the Indian and Eurasian plate with peak ground acceleration values exceeding 1g (USGS. 2015). The fault rupture propagated southeastward with maximum slip of 4-6 meters beneath the Kathmandu valley. This damaging seismic sequence was followed by hundreds of aftershocks greater than local magnitude of 4 (553 aftershocks within first 45 days) (Adhikari L.B. et al. 2015). The largest aftershock event occurred on May 12, 2015 of M7.3 about 75 km east- NE of Kathmandu

in Dolakha district with epicenter at N27.819°, E86.080° with maximum ground acceleration values of about 0.83 g (EERI 2016).

IMPACT

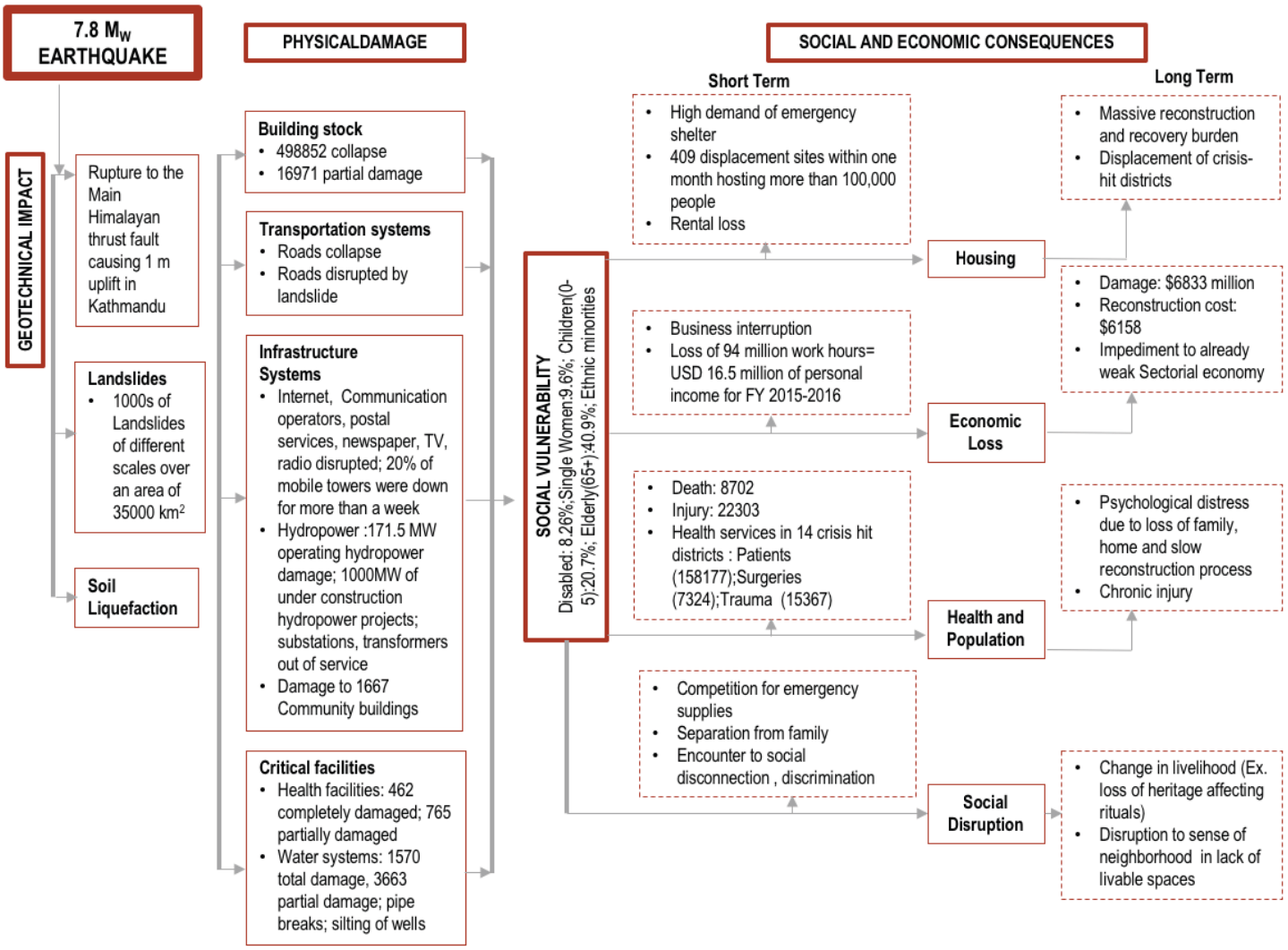
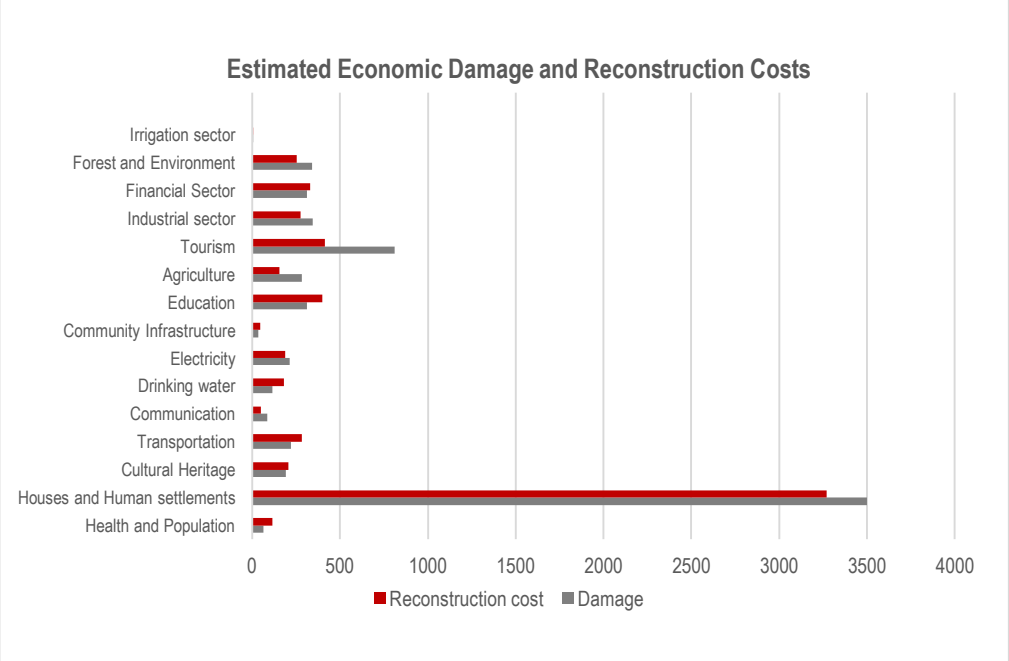


Figure 3: Impact Assessment of Nepal Earthquake 2015 (Sources: French S.P et al. 2010 ; NPC 2015; EERI 2016; IDM Nepal 2015)

Although, damage estimates of a much anticipated earthquake prior to the 2015 was extremely high, the earthquake certainly have impacted the country's development for a considerable timescale. Fig. illustrates the impact of the April earthquake that starts with the main hazard event followed by aftershocks

that triggered other disastrous conditions as landslides, liquefaction. The seismically triggered landslides in steep topographies of Nepal caused hundreds of fatalities (EERI 2016). Roads and trails were blocked that affected access to emergency response. The landslides also blocked the rivers that led to more severe circumstances to villages located downstream. Multiple sites, mostly within Kathmandu valley went through soil liquefaction that caused settlement causing foundation failure, building collapse and damage, etc. The significant physical damages determined by the loss of building stocks, infrastructure, transportation systems and critical infrastructures aggravated into prolonged social and economic consequences. 8702 people lost their lives while 22303 got injured. NPC (2015) estimates the total damage loss of USD 6833 million and the reconstruction cost to be USD 6158 million and Housing and settlement loss accounts for the largest economic impact with the total costs of USD 6770 for the damage incurred and costs to recover (Fig.). As more than 58% of the affected districts have Low strength masonry buildings, these building typology were mostly damaged followed by Cement based and RC frame structures.



The earthquake was widespread across the country, however the impact was distributed in 31 out of 75 districts and 14 districts were recorded as the most severely affected. PDNA report highlights the

uneven impact due to social, economic and spatial inequities as poorer, rural villages were adversely affected than cities. Remote districts were inaccessible for multiple days after the earthquake.

Kathmandu, the capital of Nepal, lies in the crisis hit zone as the city experienced a high amplitude with low frequency shaking due to deep lake bed deposits of the basin. The valley hosts a total of nearly 2.5million people out of which the earthquake resulted in 1729 deaths and injury to nearly two- thirds of total injured. Nearly 75,000 building were completely damaged and 60,000 partially damaged. JICA estimated more than 40,000 deaths in the valley for an earthquake similar to that of 1934 (Okamura M et. al. 2015) owing to the haphazard growth since the 1960s that makes Kathmandu more susceptible to seismic risk. Kathmandu being the prominent economic center for the country, disruptions and damage to it have larger impacts for the entire nation. However, within the valley, there was apparent uneven distribution of impact as the core cities and newer developments were affected less in comparison to peri- urban areas, historic towns on fringes and settlements of rural character that were hard hit. The following section delves deeper into the historic heritage settlements of the valley.

BUNGAMATI- A CASE OF HERITAGE SETTLEMENTS OF KATHMANDU VALLEY

HERITAGE SETTLMENTS OF KATHMANDU VALLEY

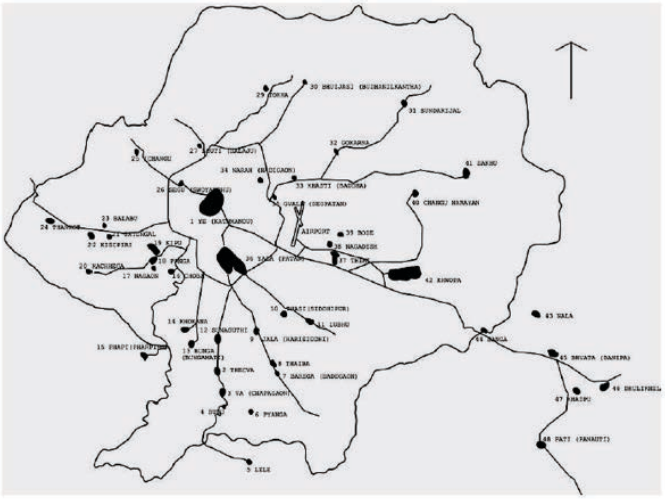


Figure 4,Mapping Heritage Settlements of the Kathmandu valley based on Ministry of Urban Development.2017

Tiwari S R. (2001) argues that there are compelling reasons to believe that the valley of Kathmandu had been in habitation since ancient times with organized reigning dating back to 1000 BC. He suggests that earlier human settlements (grama) were located on higher hills during the pre- historic Kirata period that over time evolved into commercial center (dranga) during the Lichchhavi year and moved downwards and along the hill spurs jutting into the valley floors.

This research uses the term “Heritage Settlements” to refer to the oldest settlements that started prior to the Kirata period and evolved over time in Lichchhavi and Malla era, which led to formation of medieval town centers predominantly inhabited by the indigenous population group of Newars of Hindu and/or Buddhist origins. The valley today still houses many indigenous urban settlements: 49 listed heritage settlements as shown in Fig. Owing to the historical significance of the heritage settlements and its national identity, special attention for their growth and preservation is imperative. Heritage settlements account for majority of severe

damages faced by Kathmandu valley that has led to a very critical scene in restoring the place and its people. Settlements like Sankhu had 45 deaths, 1200 houses destroyed; Khokana had 12 deaths, 1000 houses collapse, Siddhipur had 11 deaths; Harisiddhi had 23 deaths and 90% of its houses collapsed.

Although each of the settlements represent distinct social, cultural, political and built system and

Figure 5Pictures showing building damage in different Heritage settlements

have different timeline of origins, they have shared and comparable attributes as well. This research takes Bungamati as a good representative of heritage settlements of the valley.

Comparable Features between Heritage Settlements

Demographic composition

As Table illustrates, the heritage settlements of Kathmandu valley have similar areas, population and household size with average household size of nearly 4.5; slightly greater than Kathmandu municipality's household size of 3.84. Most of the houses in the settlements are resident-owned than rented. However, some of the settlements that are expanding over time have more renters. The settlements undergoing rapid change have newer building construction technologies than traditional mud-bonded foundations and walls

and more cement and Reinforced concrete structures. Most of the settlements have literacy rate higher than 70% and each settlement houses disabled population who are more vulnerable to disaster risk.

Table: Comparing demographic, household status between 10 Heritage settlements of Kathmandu Valley (Source: Census Data 2011)

	Sankhu	Machhegaon	Khokana	Bungamati	Siddhipur	Sunakothi	Thecho	Satungal	Harisiddhi	Chapagaun
Area (sq. Km)	1.38	4.66	3.17	3.89	2.01	3.02	3.26	2.33	3.1	7.27
Population (2011)	2676	3849	4927	5966	6147	10092	10136	10452	10736	16420
Population density	1934.4	825.5	1554.4	1534.3	3058.5	3344.5	3098.6	4479.8	3463.3	2257.3
Households	596	872	1056	1304	1484	2397	2352	2726	2737	3710
Homeownership	78%	99%	85%	89%	83%	60.6%	73.3%	42%	53%	70.8%
Literacy rate	78%	78%	75%	73%	77%	77%	73%	83%	80%	77%
Disabled	0.60%	1.10%	1.70%	1.60%	0.60%	1.20%	0.80%	0.80%	0.80%	1.10%
Mud bonded foundation	66%	99%	66%	74%	50%	27%	44%	19%	23%	56%

Urban Form

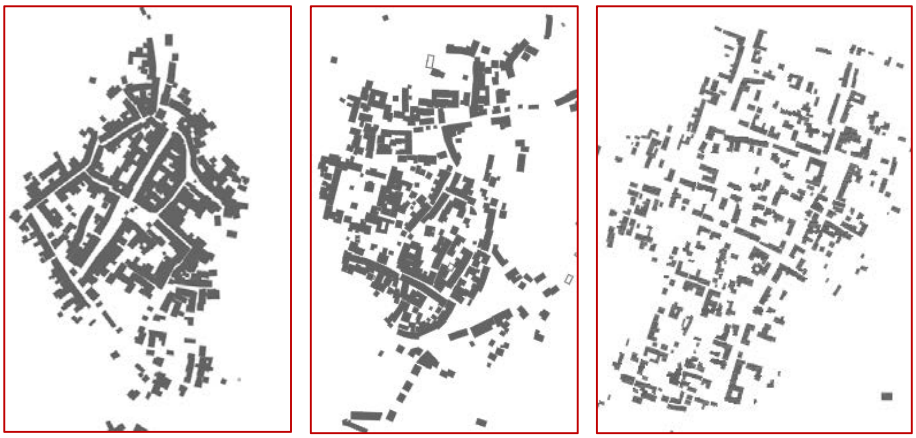


Figure 6: Comparing urban forms of Khokana, Bungamati and Sankhu

As Tiwari S R (2001) provides, heritage settlements manifest the spatial exposition of cosmic representation in a Vastu Purusha mandala pattern with demarcation of boundary by religious elements like temples, water bodies, gates, etc. The buildings are mostly 3 to 4 stories predominantly constructed using mud, brick and wood. Supporting extended families, the buildings form around courtyards and individual buildings connect to the social life by houses lined along the street with designed windows especially looking to the streets. There are pedestrian and wheel traffic path designed for various loads; and the streets function as routes for social rituals, festivals and parades. The streets are mostly brick paved and temples and public complexes mark intersection of streets. The settlements have a sense of hierarchy defined by the size of the

public complexes. Most of the settlements are palace centric with palace at the center surrounded by prime temples. Caste hierarchy define the residential layout: meaning higher caste population (high officials, traders and artisans) live near the town centers and lowest caste live in the peripheries that are near farmlands and forests. Water conduits, platforms, plinths, rest houses are other common elements of heritage settlements.

A CASE OF BUNGAMATI–RESILIENCY ANALYSIS

Bungamati is an ancient satellite Newari town 10 km south from the heart of Kathmandu city that hosts nearly 6000 people. The settlement started when King Narendra Dev (644-680AD) brought 100 families each from Kathmandu, Lalitpur and Bhaktapur after the arrival of Bunga dyo (Shrestha B K. et al.).

Built and Infrastructural Capital

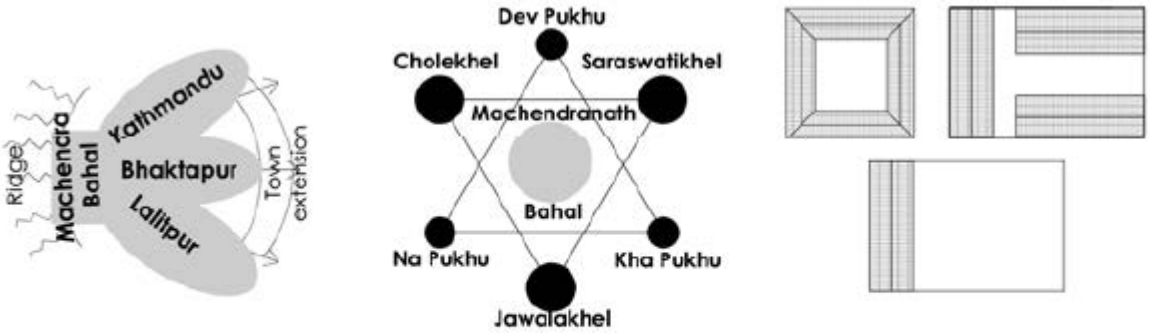


Figure 7: Formal layout of Bungamati: Community layout, Town boundary and building on plots (left to right); Source: Shrestha B K et al

The settlement is oval shaped elongating North- South with gentle slope towards the north and steep slope on the west side. The town extends in three directions mainly towards the east. The temple of Machendarantah is the anchoring node between three communities residing in three different directions- North East (Kathmandu), East (Bhaktapur) and South East (Lalitpur). Higher ranked caste as Shakyas, Vajracharyas live close to temple. Each community has separate artificial pond – Dev Pukhu for Shakya community from Kathmandu, Kha Pukhu for Shrestha family form Bhaktapur and Na Pukhu for Jyapu community from Lalitpur.

Open spaces at peripheral areas (Cholekhel, Saraswatikhel and Jawalakhel) and the ponds delimit growth towards the agricultural fields. The buildings are similar to other Newari settlements but unique architecturally mostly expressed through its famous wood works. Majority of the buildings are mud, brick and wood construction. Nevertheless, there are haphazard infill developments with modern technology disrupting the architectural fabric of the place. Transition form extended to single family system have encouraged vertical division in traditional building stocks with unmonitored renovation. There are ample multifunctional public spaces and amenities in the form of temples public squares, monastery squares, rest houses, plinth areas, water conduits, etc. Commercialization, misuse and encroachment and neglect of cultural spaces are noticeable issues.

Figure 8: Map showing activity pattern and cultural heritages

Streets are short; irregular patterned and follows the land topography with junctions marked by community amenities. The vehicular roads: 3-4.5m black topped lie in the periphery while the inner streets are mostly

pedestrian: 2- 3m wide brick and stone paved. The streets serve Figure below illustrates connectivity, integration and choice of the street networks. Red indicates the street with highest connectivity value; most integrated node with the system as a whole; and most used path while blue shows the least connected; segregated node and least passed element while calculating the shortest path respectively. There is variation in connectivity levels of the different streets where the middle street extends and connect to the road towards capital city is the most connected, the vehicular street near the bus stop(Fig) is the second most connected. The entire street network is well integrated and most of the streets can be easily reached. And, there are good amount of streets that indicate the most used in terms of the shortest distance between the elements. Overall, the spatial connectivity of Bungamati is good. However, the internal roads are mostly pedestrian that on one hand enhances walkability and health of the community, but during the earthquake most of these routes were blocked by the collapsed buildings.

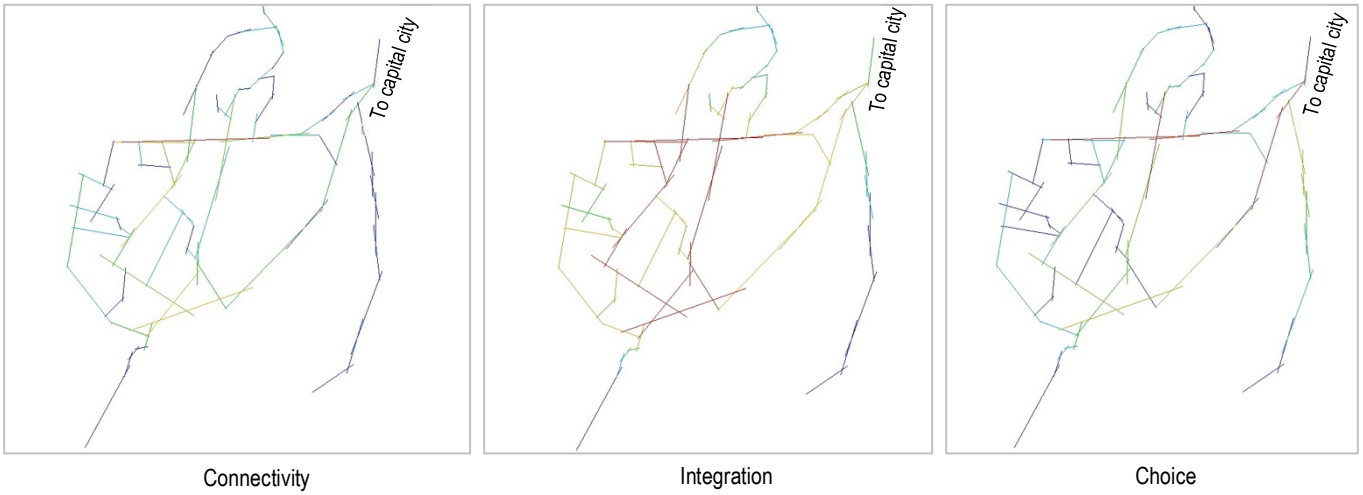


Figure 9: Space syntax analysis: Connectivity, Integration and Choice mapping (Created using Depthmap)

The earthquake killed 6 people and injured 50 and out of 1114 houses, 850 were destroyed along with the most significant temple of Machhendranath (Fig.). The age of the buildings and the traditional construction technology using mud mortar, mud brick and wood without appropriate earthquake resistance caused the massive level of damage.

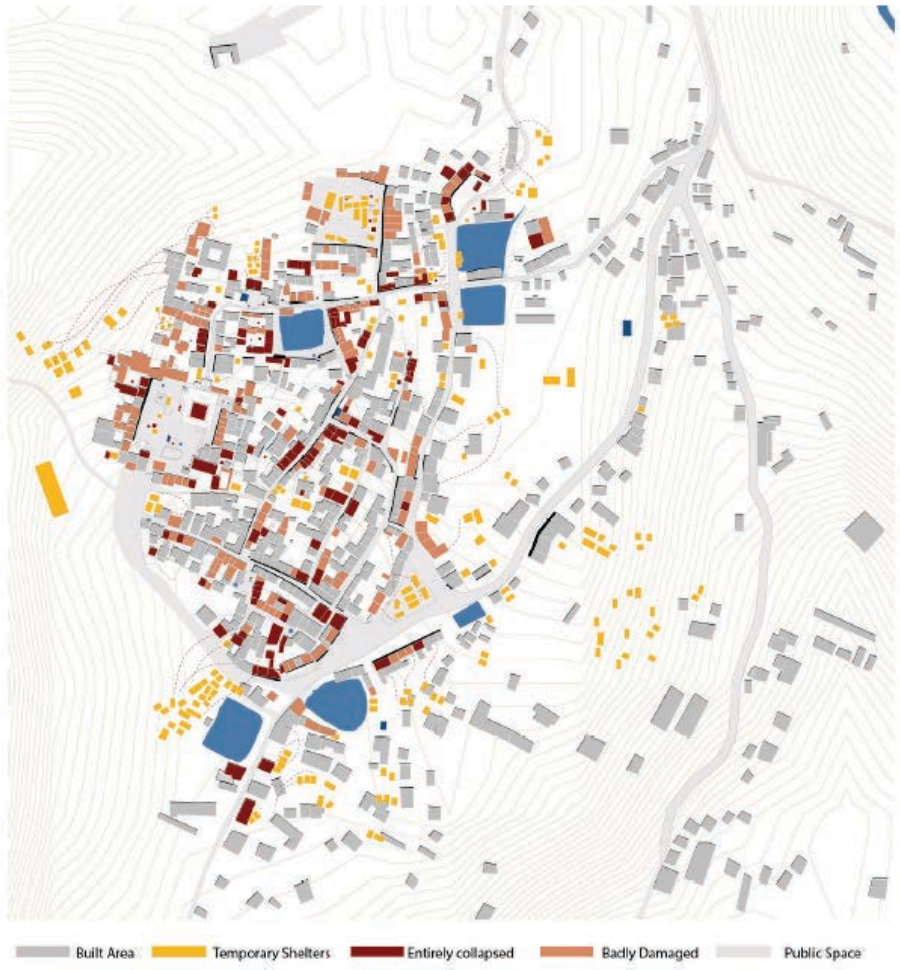


Figure 10: Damage Impact of 2015 earthquake (Source:KU Leuven)

Bungamati's water supply system consists of 5 wells, 2 stone spouts, 6 public water taps and 5 ponds. The ponds are dried off or polluted with garbage disposal, sewer discharge, etc. The implementation of piped system in many households shifted the use of well water for washing clothes, bathing and drinking. The earthquake destroyed majority of pipeline and water supply was a critical issue as the community was short of water supply.

The weak built structures and decline in infrastructural elements and uncontrolled growth puts Bungamati's built and infrastructural capital in a very weak state. Nevertheless, the settlement holds a great

potential for physical resilience due to its dense, diverse, connected spatial layout, multifunctional open spaces and rich cultural heritage. Public spaces played a prominent role in providing spaces for emergency temporary shelters, debris collection as well as facilitated for supplying emergency supplies and services after the earthquake.

Natural Capital

The settlement is surrounded by farmlands with fertile soil with easier access to farm inputs with surplus food balance even with lesser per capita landholding (Maharjan K L et al. 2007). Vernacular architecture that suit the local climate pose minimum impact to the environment. Bhattarai A et al. (2011) notes Bungamati has very low Cumulative Environmental Behavior index associated to higher density, less land mass, non motorized access to services, dietary habits and waster production. Water pollution, sewer and garbage disposal are some of the environmental problems. In terms of disaster, Bungamati is one of the settlements susceptible to liquefaction although no major problem was seen in 2015 earthquake.

The natural capital of Bungamati is fairly strong with some issues of sanitation and pollution.

Human and Social Capital

Bungamati has a total population of 5996 with almost half male and female population. Predominantly Newar , Shakya, Maharjan and Tuladhar are the dominant caste. Fig shows the grouping of housing and temporary shelter arrangement as per the ethnic identity. Based on the Hindu caste structure, some population belong to the untouchable group that brings struggle with the idea of tolerance in social interaction. However, the community share commonalities on cultural grounds as the community celebrate religious festivals, social events together. The parade of Machhendranath chariot is one of the most significant ritual that binds the community and builds relation to people from all over the country.

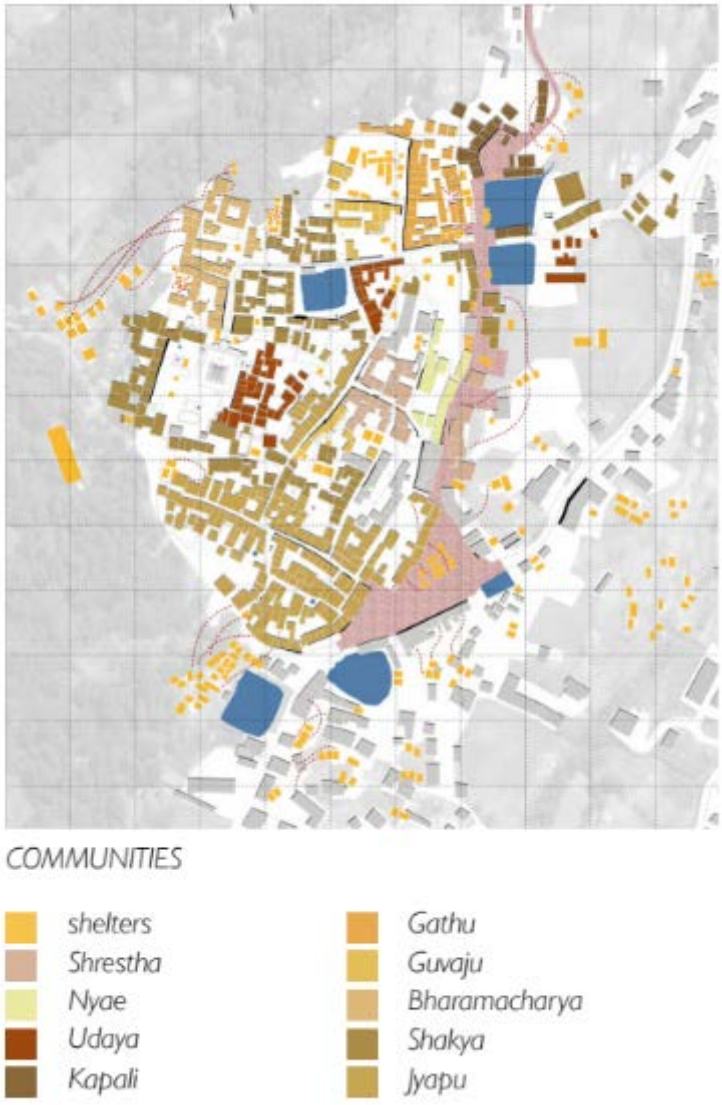


Figure 11: Residential cluster according to Caste

Woodcarving is the most significant skill of the community and a source of income mostly for Shakyas and Tuladhar community whereas other communities have adopted the profession as side jobs as well. 73% of the total population can read and write, however more than 50% have education level up to or below tenth grade. People of lower caste, people with disability, women, children, low education level are vulnerable to social, economic stresses that is aggravated by the earthquake. Gurung P (2000) provides

evidences of declining social bonding seen in competition for prestige and economic growth, providing help in agricultural tasks, etc.

Therefore, Bungamati has weak human and social capital. The community is near to another heritage settlement – Khokana lying on the Northwest, but is mostly disconnected to other surrounding neighborhoods and city that deprives it from the day to day encounter to difference that Sennet R (2011) argues crucial for social competence and maturity. However, the earthquake also exposed many active community groups and individual leaders and volunteers from other parts of Kathmandu valley.

Economic capital

Bungamati is predominantly an agricultural community along with significant woodcarving industry (of male domain). However, low returns of woodcarving, changing building construction and expensive wooden technology pose threat to the sustainability of the industry and people engage in wood works as a side job. In some of my interactions with the residents some weeks after the 2015 earthquake, many of them expressed their concern regarding threat to their income source reliant on woodcarving and job loss. One of the residents with skill in traditional music was job less for a long period of time even prior to earthquake due to eroding culture and lack of demand.

Bungamati is significantly weak in terms of its economic capital. Post earthquake, the entire community is relying on external funding.

Institutional Capital

Guthis, the social institutions with responsibility to manage all the communal amenities, are typical political capital of Newari settlements. Traditionally land was donated to the Guthi in order to generate income necessary to carry out the management works as renovation of communal buildings, cleaning temples, water bodies, drainage; carrying out funeral rituals, etc. Bungamati have different purpose guthi systems. However,

in the last 50 years, the guthi system has eroded with the dispersion of guthi members and conversion of guthi lands into personal properties. The degrading cultural heritage is also linked to the demise of guthi system that furthers the weakening of social network.

Likewise, as Bungamati is under the jurisdiction of a Village Development Committee, new buildings do not require detail blue prints causing haphazard construction. The weak governance system, lack of master plan or conservation plan to orient growth as well as little concern from Department of Archaeology, Ministry of Culture, UNESCO; lack of disaster preparedness strategies reveal the weaknesses of institutional capital.

To conclude, Bungamati has a weak overall community capital. The strongest capital is the spatial and cultural aspect of the built capital that provides a significant opportunity to direct growth of capital in each sector. The community's capital was undergoing decline since decades prior to the earthquake; the damage created by the earthquake in such state of decline is some what obvious. Hence, in order to strengthen the resilience of Bungamati, the stronger aspect of each sector should be leveraged and weaker side should be strengthened.

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REBUILDING EFFORTS

There are multiple agencies, groups, academicians, volunteers actively working ever since the earthquake struck. The response process operated at multiple levels from international rescue groups, Nepal's military to volunteers all across Nepal as well as other nations.

It has been more than two years since the 2015 earthquake and the reconstruction process is extremely slow primarily due to Nepal's weak governance. Nepal's political environment is not a stable one as institutional bureaucracy, corruption and competition for power are political norms. Post earthquake, events like constitution issuance, multiple election of prime ministers created several political conflict; the most damaging was Indian embargo for three months that started in September 2015. Inadequate coordination, inexperience of construction management, lack of financial and human resources are some of the barriers to the reconstruction process.

Although laws, policies, and plans for disaster response, such as the National Strategy for Disaster Risk Management (2009), the Draft Disaster Management Act (2015), and the National Disaster Response Framework (2013) did provide a framework for a national response the framework could not deliver what it seemed to promise (Manandhar M D et al. 2017). The National Reconstruction Authority (NRA) that was established in late December 2015 only began operations after mid January 2016 and effective coordination between the NRA, local governments, and line agencies as well as between the NRA and other development organization has been a continuing challenge in the process. KC A (2017) observes lack of elected official at the local level as the main challenge to preparedness as well as recovery process.

EVALUATION OF REBUILDING BUNGAMATI

Bungamati is one of the communities that has received most attention in the post disaster response and recovery process. (KU) Kathmandu University's College of Art department was the first set of volunteering group in the response process. In the immediate emergency phase, KU helped with building temporary shelters, conducted art healing workshops, etc. There were multiple groups of volunteers of engineers for preliminary assessments, doctors for free checkups, others for food and water provision.

Immediate temporary shelters were built by community and provided by the government. However, with the slow demolition, debris removal and strategies for reconstruction, the community are still living in the temporary shelters provided by Danish peoples Aid, Centre for Integrated Urban Development, Nepal and other NGOs and foundations.

Currently, UN Habitat in partnership with KU Leuven is running a rebuilding initiative for Bungamati with the focus on physical development (housing, public spaces and infrastructures), economic development (tourism, livelihood) and social development (community participation, heritage conservation).

Physical Development

1. **Revitalizing Bungamati Action Plan**: The action plan is focused on urban design strategies that take into account the genius loci, incorporate local housing traditions, and integrate local economies and heritage. There are 2 components of the plan. One operates at the larger scale and aims to connect Bungamati with Khokana at North west and other looks into instigate growth within Bungamati.
    - Twin village Armature: The plan anticipates expansion of settlements and suggest relocation units for reconstruction between Khokana village at Northwest and Bungamati and proposes a connector to delimit growth in both the settlements while activating the area around

Karyabinayak temple located between the two settlements by combining ecological and water management strategies in a designed landscape.

- Renewal of Bungamati: This part of the plan aims to structure public space, develop pilot projects and set a timeline for actions.

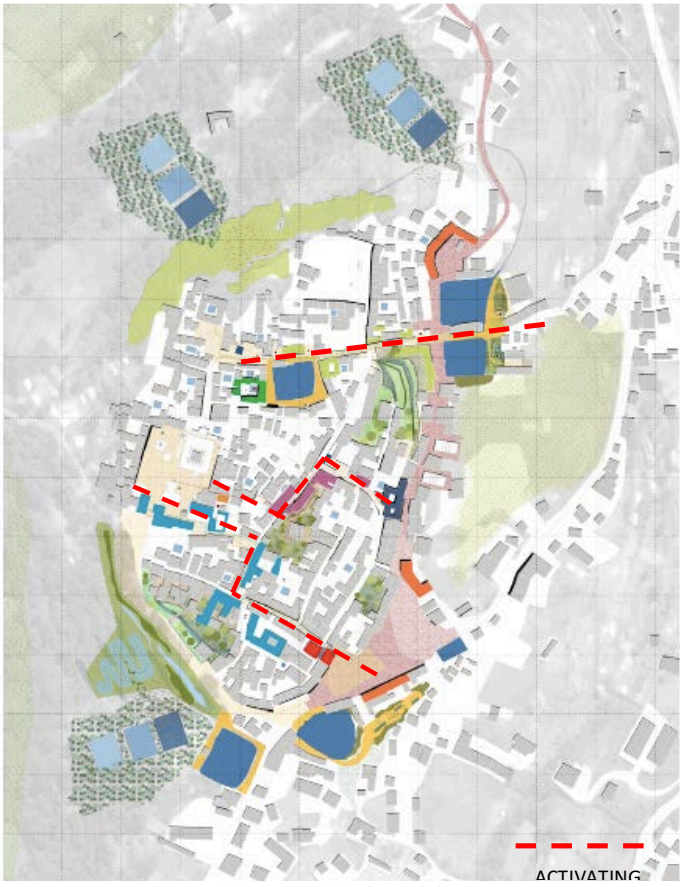

Figure 12Revitalizing plan

As shown in Fig. the plan proposes green structures and open spaces with the motive of treating community waste water and rainwater harvesting in the existing ponds and multiple micro scale water collection points to achieve ecological resilience. Other important part of the proposal is to activate three routes. The top-most route for activation is the most connected street of the settlement. Developing the street stretch is most suited for activating the entire settlement. This route has a pilot project of a courtyard housing that is designated for temporary housing the settlers in public squares. The second route for activation are moderately integrated and not very connected routes according to space syntax analysis. Proposing carpenters house in this route could be useful for creating more connection while building on the existing community skills. The third route lies on moderately connected and highly integrated network. This can help the success of proposed pilot project of a social restaurant in that route. The pilot projects: courtyard housing, social restaurant and carpenter house might be useful catalyst to trigger growth and tourism as seen in other tourism oriented traditional communities in the valley.

2. Open Space Management

3. Jawalakhel Park Development

4. Housing Typologies Design Options

5. Neighborhood Development Plan

6. Establishment of Technical Support Office to facilitate in design of individual houses

Economic Development

1. Establishment of Nepal Higeisen and Allied Industries:
    - Community based Brick manufacturing company (50% investment by community and 50% by Chinese company)
2. Artists' Atelier – Artist for Nepal with KU
    - Directed to provide training to woodworkers

- Certificate program in woodcarving

Social Development

1. CTEVT Training for masons and carpenters
2. Bungamati Area Reconstruction and Development Council
    - A council of 101 members representing stakeholders including guthis, local organizations, political parties, women's group, etc.

MOVING FORWARD

The Bungamati Rebuilding plan is still largely under the process of achieving the list of objectives noted above. Looking at Bungamati's state prior to and after the earthquake, the community's resilience expresses a complicated relationship between the community's capital. The most damaging impact of the earthquake was seen in the destruction of buildings. The Rebuilding plan especially the Revitalizing plan is incremental in its approach that is helpful for the community to move ahead while considering the future scenario of growth around the community. Although, the process approached by UN Habitat is aimed to be of highest participation, it is hard to understand the use of community inputs at this stage. The building design aspect of the plan is the most important yet slowed process as the Bye laws and building code post earthquake took to long to be created and released.

As resiliency is defined by the strength of a community/systems capital, the rebuilding process and plans look at the recovery and reconstruction process only. The preparedness strategies for the community in next big earthquake requires higher level of social capital. Engaging the community in planning process is likely to strengthen social competence of community by providing knowledge of the future oriented perspective. However, mechanisms to strengthen the social networks need more focus. Connected public spaces are the most useful assets of Bungamati. Planning to use the public spaces as multifunctional units of innovation in disaster should be one of the strategies. Technologies to include warning systems, water supply, power storage, water treatment, solar can be included in the public spaces as rest houses, public platforms, etc. (MIT.2016). Most of the heritage settlements have narrow street network mostly designed to hold pedestrian traffic. During the earthquake, the streets were blocked by building damage that hindered the emergency supply and reach. Hence, it is crucial to look at the physical form of these settlements and map the disconnected streets and vulnerabilities associated to them.

Bungamati being one of the most reached out community helped people more to get out of the traumatic experience and loss by constant engagement from people all around the world. However, other heritage settlements that are not as easily accessible might not have the same level of support. Harisiddhi, a town 4 km from the capital city's main network protested for not receiving emergency supplies and other supports. For communities as such, it is not always the external support that will help the settlement get out but the community's own resiliency. Hence, focusing on the community's capital and planning to strengthen all the elements of it is very important for establishing the resiliency of Heritage settlements.

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